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Impact of order set design on urine culturing practices at an academic medical center emergency department

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Abstract

Background—Urinalysis and urine culture are commonly ordered tests in the emergency department (ED). We evaluated the impact of removal of order sets from the “frequently ordered test” in the computerized physician order entry system (CPOE) on urine testing practices.

Methods—We conducted a before (1 September to 20 October 2015) and after (21 October to 30 November 2015) study of ED patients. The intervention consisted of retaining “urinalysis with reflex to microscopy” as the only urine test in a highly-accessible list of frequently ordered tests in the CPOE system. All other urine tests required use of additional order screens via additional mouse clicks. The frequency of urine testing before and after the intervention was compared, adjusting for temporal trends.

Results—During the study period, 6499 (28.2%) of 22,948 ED patients had ≥ 1 urine test ordered. Urine testing rates for all ED patients decreased in the post-intervention period for urinalysis (291.5 pre- vs. 278.4 per 1000 ED visits post-intervention, p=0.03), urine microscopy (196.5 vs. 179.5, p=0.001) and urine culture (54.3 vs. 29.7, p <.001). When adjusted for temporal trends, the daily culture rate per 1000 ED visits decreased by 46.6% [−46.6%, 95% confidence interval (CI): −66.2, −15.6%], but urinalysis (0.4%, 95%CI: −30.1, 44.4%), microscopy (−6.5%,

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95%CI: −36.0, 36.6%) and catheterized urine culture rates (17.9%, 95%CI: −16.9, 67.4) were unchanged.

Conclusions—A simple intervention of retaining only "urinalysis with reflex to microscopy' and removing all other urine tests from the "frequently-ordered" window of the ED electronic order-set decreased urine cultures ordered by 46.6% after accounting for temporal trends. Given the injudicious use of antimicrobial therapy for asymptomatic bacteriuria, findings from our study suggest that proper design of electronic order sets plays a vital role in reducing excessive ordering of urine cultures.

Keywords

test utilization; urinalysis; urine culture; emergency department; computerized physician order entry

Introduction

Urinalysis and urine culture are commonly ordered tests in the emergency department (ED) (1). However, the diagnostic yield of urine culture for patients with undifferentiated abdominal pain is low and urine cultures are not recommended for evaluation of uncomplicated urinary tract infections (UTI) (1). Urine cultures performed without clear clinical indications increase healthcare costs and contribute to the unnecessary treatment of asymptomatic bacteriuria (ASB) (1, 2). Despite several recommendations, antimicrobial therapy directed against ASB remains common in clinical practice and may promote antimicrobial resistance (3).

Previously examined interventions to reduce unnecessary urine culture tests have included automatic cancellation of urine cultures for specimens with low-risk urinalysis (1), two-step urine culture ordering (4) and antimicrobial stewardship efforts (5). Jones et al (1) developed a reflex urine culture cancellation protocol in the ED based on low-risk findings (negative nitrites, negative leukocyte esterase, negative bacteria and ≤ 10 WBC per high-power field) for infection on urinalysis and concluded that using these criteria would have eliminated 39% of unnecessary cultures. Stagg et al (4) implemented a two-step model for urine culture ordering in the ED which resulted in decrease in urine cultures processed, a decrease in callbacks for positive results and an improvement in antimicrobial prescribing for UTI. Other quality improvement projects include antimicrobial stewardship efforts where antibiotic recommendations were made based on the culture results (5). However, there are limited data on design and location of the urine culture order sets and its role in ED urine testing practices.

In this study, we retained only "urinalysis with reflex to microscopy' and removed all other urine orders from the "frequently-ordered" order set within a computerized physician order entry system (CPOE). We then evaluated the impact of this change on urine testing practices in the emergency department of an urban, academic medical center.

Methods

Study Design and Setting

We conducted a before-after study of all patients seen at our hospital ED between 1 September 2015 and 30 November 2015. This ED averages approximately 93,000 patient visits annually.

Electronic order sets/ Intervention

Urine order sets at our hospital ED are commonly ordered from the drop down menu of highly-accessible "frequently ordered tests" in the CPOE system. The urine order sets available in "frequently ordered tests" and the corresponding definitions are illustrated on Table 1. On 21 October 2015 a quality improvement project was implemented to reduce unnecessary urine cultures. The intervention consisted of removing the orders for "*urinalysis with reflex to culture*", "*urine macroscopic*" and "*urine microscopic*" from this highly-accessible list of "frequently ordered tests" in the CPOE system, while retaining only "*urinalysis with reflex to microscopy*" (Table 2).

During the entire study period, "*urinalysis with reflex to microscopy*", "*urinalysis with reflex to culture*", "*urine macroscopic*" and "*urine microscopic*" were available through a specialized list of "hematology/coagulation/urinalysis and microbiology" orders requiring two additional mouse-clicks and an order for "*urine culture*" alone was available in the "microbiology" order set requiring three additional mouse-clicks to access. ED attending and resident physicians were educated about this change through in-person education and electronic correspondence. No additional interventions were implemented during the study period related to urine culture order sets.

Data collection

Patient and laboratory data were abstracted from the hospital electronic medical informatics database. Data included ED patient demographics, laboratory test results (urinalysis, microscopic exam and urine culture), and disposition. The medical informatics database does not include orders, only tests results. For urine cultures with accompanying urinalysis or microscopy, the time between the culture and urinalysis and/or microscopy was calculated. The presence of an indwelling urinary catheter was identified based upon specimen type indicated by the ordering clinician. For patients with multiple urine tests, we treated each sample as an independent observation. Urine cultures that were no growth or contaminated were considered negative for this analysis. Any growth ≥50,000 colonies/ ml for clean catch specimen and ≥5,000 colonies/ml for catheterized specimen are treated as positive urine culture results. Leukocyte esterase ≥1 identified on urinalysis and >5 white blood cells per high power field on urine microscopy were treated as abnormal/positive test results.

Statistical analysis

We compared patient and urine testing data during the 50 days preceding and 41 days following the intervention (Wilcoxon Rank Sum test, χ^2 or univariable logistic regression where appropriate). Demographic characteristics were compared only for patients with ≥ 1 urine test (i.e., urine culture, urinalysis and microscopy) ordered during their ED visit whereas urine testing rates (per 1000 ED patient visits) were calculated for entire study period, pre-intervention and post-intervention period using the ED visits as the denominator. Regression modeling with Auto Regressive Integrated Moving Average (ARIMA) errors was used to test the significance of the percentage (%) change in the daily urine tests ordered per 1,000 ED patient visits, adjusting for temporal trends in the data. Data were analyzed using SAS version 9.3 (SAS Institute, Cary, NC).

Results

Patient characteristics

During the study period, 6499 (28.2%) of 22,948 ED patients had ≥ 1 urine test ordered [3711 / 10,102 (28.9%) pre- vs. 2788 / 12,846 (27.6%) post- change; p=0.03]. Median age of all patients with ≥ 1 urine test ordered was 46 years (interquartile range, 30–62). Approximately 57% of patients were black and 62.4% were female. There were no differences in gender, race, or discharge status pre- versus post-intervention (Table 3).

Urine testing

Urine testing rates decreased in the post-intervention period for urinalysis (291.5 pre- vs. 278.4 per 1000 ED visits post-intervention, p=0.03), urine microscopy (196.5 vs. 179.5, p=0.001) and urine culture (54.3 vs. 29.7, p <.001). Post-intervention, there was no change in the proportion of positive urinalyses [1428 / 3744 (38.1%) pre- vs. 1125 / 2812 (40.0%) post-intervention; p=0.08] or urine cultures [270 / 697 (38.7%) pre- vs. 122 / 300 (40.7%) post-intervention; p=0.43] (Figure 1). When adjusted for overall temporal trend, the daily culture rate per 1000 ED visits decreased by 46.6% [−46.6%, 95% confidence interval (CI): −66.2, −15.6%], but urinalysis (0.4%, 95%CI: −30.1, 44.4%), microscopy (−6.5%, 95%CI: −36.0, 36.6%) and catheterized urine culture rates (17.9%, 95%CI: −16.9, 67.4) were unchanged.

Type of urine cultures ordered

Since we could not directly assess if urine reflex testing was ordered, we approximated the type of urine cultures ordered (i.e., urinalysis with reflex to culture vs other) using the specimen collection time for urinalysis/ urine microscopy compared to urine culture collection time. We assumed that urine tests with simultaneous collection times to represent reflex testing. A review of the patient charts from a small, random sample of cultures collected within 10 minutes of urinalysis/ urine microscopy group found these to be “urinalysis with reflex to culture” orders (data not shown). As shown on Table 4, tests per 1000 ED visits for all types of urine cultures decreased significantly post intervention (p<0.05) except for urine cultures obtained > 10 minutes after urinalysis/urine microscopy.

Subsequent urine culture testing in hospital

To determine if an admitting service felt a urine culture was “missed” in the course of ED care, we evaluated patients subsequently admitted to hospital who had either urinalysis or microscopy test obtained in the ED, but no urine culture (n=2375). There was no significant change in the proportion of individuals who had a urine culture ordered in the hospital within 24 hours of an ED urinalysis and/or microscopy [64 / 1272 (5.0%) pre- vs. 75 / 1103 (6.8%) post-intervention; p=0.07] or at any time during hospitalization [121 / 1272 (9.5%) pre- vs. 131 / 1103 (11.8%) post- intervention; p=0.07].

Discussion

We found that removal of certain urine testing orders from the frequently ordered test window in the ED CPOE system was associated with a 46.6% reduction in urine cultures ordered in the ED, without significant changes in the frequency of urinalysis and microscopy tests ordered, and the proportion of the positive urine cultures, after accounting for temporal trends.

The ED is one of the most common locations for urine testing, yet previous efforts to reduce unnecessary urine cultures, including education, have had limited success (6–8). In a recent study by Stagg et al (4) institution of a two-step model for urine culture ordering resulted in a decrease in the number of unnecessary urine cultures processed, a decrease in patient callbacks for positive results and improved antimicrobial prescribing for UTI. The Step 1 included an order for urine analysis and urine culture and Step 2 included processing the urine for culture and susceptibility (if required) after an ED physician assessment. Healthcare providers were educated about the intervention and the goal of reducing urine culture rates. However, the authors reported no significant decrease in the total number of urine cultures ordered in the intervention period. Jones and colleagues demonstrated that a reflex urine culture cancellation protocol in the ED, based on low-risk findings for infection on urinalysis, would have eliminated 39% of unnecessary cultures (1). Although this reflex urine culture cancellation protocol was externally validated by Hertz et al (9), these were mainly derivative studies using retrospective data and were not prospectively implemented. While stewardship efforts (5) reduce unnecessary antibiotic prescriptions and the associated costs, they are time-intensive interventions and require constant monitoring. The effect of removing multiple urine testing orders from a frequently ordered test set on ED physician ordering practices has not been previously well-described.

Our intervention showed that retaining only “urinalysis with reflex to microscopy’ and removing all other urine tests from a list of frequently ordered tests in the ED CPOE led to a 46.6% reduction in urine cultures ordered in the ED. We also evaluated for possible shift of urine culture testing to in-hospital locations among admitted patients and found no significant change. By removing these order sets, ED physicians were made to order the urine cultures alone through deeply embedded order sets which required 3 additional mouse clicks. Relatively simple changes in CPOE preferences can greatly alter clinician ordering practices. Olson *et al* reported that pre-selecting a post-transfusion hematocrit order within a red cell transfusion order set increased frequency of testing from 8.3% to 57.4% after transfusion (10). Similar findings were observed for CPOE use in managing congestive heart failure (11), analgesic treatment for renal colic (12), and sepsis (13). According to the Medicare Clinical Laboratory Fee Schedule, our intervention resulted in savings of $5,955 during the study period ($10,455in the pre-period vs. $4,500 in the post intervention, at national median Medicare payment rate of $15.00 per urine culture)(14).

We focused mainly on the “urinalysis with reflex to culture” as it is a standard order set across many institutions which avoids recollection of urine. ED physician and resident education may have influenced the fewer urine culture orders in the post-intervention period, but this was unlikely as the education was mainly notification of the removal order sets and not about reducing urine culture rates. Though we noticed a slight drop in the urinalysis and urine microscopy rates post-intervention, this was not statistically significant when adjusted for temporal trends using ARIMA modeling. The slight drop in the rates may be due to the removal of “*urine macroscopic*” and “*urine microscopic*” from the list of “frequently ordered tests”. Also there might have been a change in the ED patient population over time, due to this study occurring over the start of influenza season in our region (15).

Limitations of our study include retrospective design, absence of chart review and generalizability of results because of single center study setting. Due to the nature of the laboratory database in our hospital, we were unable to get the actual frequency of urinalysis with reflex to culture vs other ways of ordering the urine cultures directly from the database. However, we used the collection time to determine if the urine cultures ordered were part of the urinalysis with reflex to culture vs other ways of ordering. We also did not have data on antibiotic use, limiting the assessment of positive urine cultures for antimicrobial therapy directed against asymptomatic bacteriuria. Although there was no significant change in the proportion of individuals who had a urine culture ordered in the hospital within 24 hours of an ED urinalysis and/or microscopy, our study may be underpowered to detect a change. Strengths of our study include a large sample size and the use of an automated electronic intervention that can be easily replicated at other institutions employing CPOE. We also adjusted for overall temporal trends to account for autocorrelation due to patient mix and influenza season.

Results of our study complement recent intervention studies to improve urine culture practices, such as two-step urine culture ordering (4), reflex urine culture cancellation protocol (1, 9), pharmacist driven antimicrobial stewardship efforts (5), distribution of a pocket card to clinicians outlining a diagnostic algorithm for UTI diagnosis with case-based audit and feedback (2) and suppression of urine culture results from non-catheterized inpatients (16).

In conclusion, we found that retaining only “urinalysis with reflex to microscopy’ and removing all other urine tests from a frequently-ordered electronic order set resulted in a 46.6% reduction in urine cultures obtained in the ED. This supports the hypothesis that minor changes in CPOE design can have a significant impact on physician ordering practices. Further studies are needed to evaluate the role of CPOE across the spectrum of care to reduce excessive urine culture testing and prevent unnecessary antimicrobial use.

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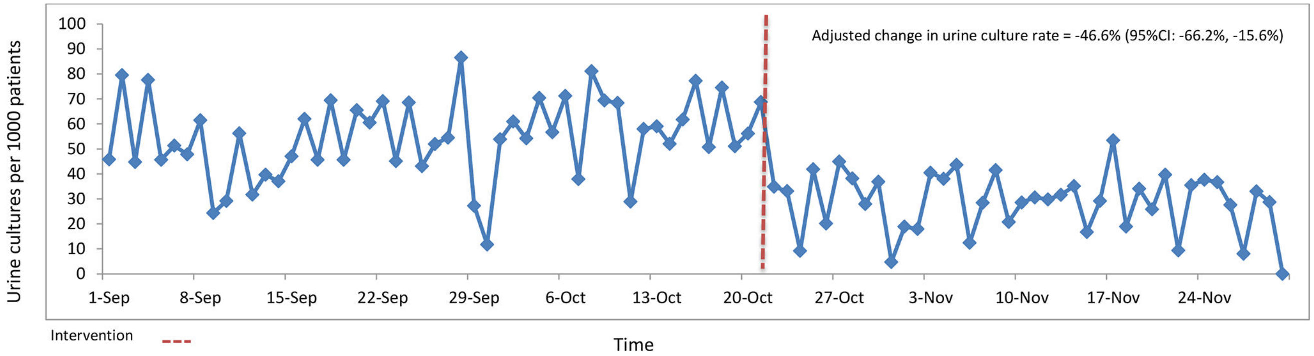

Figure 1.

Urine Culturing Practices in Emergency Department (Sept 1, 2015 – Nov 30, 2015)
*Adjusted for overall temporal trend on Autoregressive Integrated Moving Average (ARIMA); CI-confidence interval

Table 1

Urine order set definitions

Urine order set	Definitions
Urinalysis with reflex to Microscopy	Perform urine dipstick, if positive for protein> trace, any blood then reflex to microscopy
Urinalysis with reflex to culture	Perform urine dipstick, if positive for protein> trace, any blood, nitrite or leukocyte esterase then reflex to microscopy and urine culture
Urine Macroscopic	Macroscopic Dipstick Urinalysis only
Urine Microscopic	Urine Sediment Examination only

Table 2

Changes in the urine order sets within study Emergency Department

Category	Pre-Intervention	Post-Intervention
Frequent Labs		
	Urinalysis with reflex to Microscopy	Urinalysis with reflex to Microscopy
	Urinalysis with reflex to culture	
	Urine Macroscopic	
	Urine Microscopic	
Heme/Coag/UA (Required 2 additional mouse clicks)		
	Urinalysis with reflex to Microscopy	Urinalysis with reflex to Microscopy
	Urinalysis with reflex to culture	Urinalysis with reflex to culture
	Urine Macroscopic	Urine Macroscopic
	Urine Microscopic	Urine Microscopic
Microbiology (Required 3 additional mouse clicks)		
	Urine culture	Urine Culture

*Urinalysis- urine macroscopic examination; Heme/Coag/UA- Hematology/ Coagulation/ Urinalysis

Table 3

Comparison of 6499 patients who had any urine testing in the ED before and after intervention

	Study Cohort*	Pre-Intervention (Sep 1st to Oct 20th)	Post-Intervention (Oct 21st to Nov 30th)	P-value
Patient Characteristics	N=6499	N= 3711	N=2788	
Age, median (IQR)	46 (30–62)	46 (29–62)	46 (30–62)	0.88
Race, n (%)				
White	2499 (38.5)	1453 (39.2)	1046 (37.5)	Ref
Black	3687 (56.7)	2086 (56.2)	1601 (57.4)	0.22
Other	313 (4.8)	172 (4.6)	141 (5.1)	0.28
Sex, n (%)				
Male	2441 (37.6)	1406 (37.9)	1035 (37.1)	0.53
Female	4058 (62.4)	2305 (62.1)	1753 (62.9)	Ref
Discharge status, n (%)				
Admitted to hospital	2916 (44.9)	1625 (43.8)	1291 (46.3)	0.55
Discharged to home from ED	3314 (51.0)	1931 (52.0)	1383 (49.9)	0.84
Discharged to other facility/ Expired/AMA^	269 (4.1)	155 (4.2)	114 (4.1)	Ref
Urine Testing Practices				
Urinalysis, n, (per 1000 ED visits)	6556 (285.7)	3744 (291.5)	2812 (278.4)	0.03
Leukocyte esterase positive, n (%)	2553 (38.9)	1428 (38.1)	1125 (40.0)	0.08
Urine Microscopy, n, (per 1000 ED visits)	4408 (192.1)	2524 (196.5)	1813 (179.5)	0.001
Urine Microscopy Result (WBC/ hpf), n (%)				
≤ 5	2540 (57.6)	1500 (59.4)	1040 (55.2)	Ref
>5 – 49	1209 (27.4)	675 (26.8)	534 (28.3)	0.06
≥50	659 (15.0)	349 (13.8)	310 (16.5)	0.005
Urine Cultures Performed, n, (per 1000 ED visits)	997 (43.4)	697 (54.3)	300 (29.7)	<.0001
Positive culture, n (%)	392 (39.3)	270 (38.7)	122 (40.7)	0.43
Catheterized cultures, n, (per 1000 ED visits)	49 (2.1)	22 (1.7)	27 (2.7)	0.0002
Isolated culture, n (%)**	25 (2.5)	16 (2.3)	9 (3.0)	0.51

ED: Emergency department; IQR: Inter quartile range; AMA: Against medical advice; WBC: White blood cells; hpf: High power field

* Patient visits to ED whose urine was tested (≥ 1) either for dipstick, microscopy or culture at ED during the study period. Overall 22,948 patients visited ED during Sept 1 – Nov 30 2015, 12846 during Sep 1 to Oct 20 (pre-intervention) and 10102 during Oct 21 to Nov 30 (post-intervention)

^ other facility- 265, Expired -4; Pre-intervention: other facility-152, expired-3; Post-intervention: other facility-113, expired-1;

** Isolated is defined as a urine culture performed without either a urinalysis or urine microscopy within 24 hours before or after the culture

Table 4

Type of urine cultures ordered, based upon collection time

	Pre-intervention		Post-intervention		P-value
	N	Tests per 1000 ED visits	N	Tests per 1000 ED visits	
Simultaneous urine culture and urinalysis collection times (approximating urinalysis with reflex to culture)	264	20.6	99	9.8	<0.0001
Urine cultures collected less than 10 minutes of urinalysis/urine microscopy	242	18.8	62	6.1	<0.0001
Urine cultures obtained > 10 minutes after urinalysis/urine microscopy and urine cultures without any urinalysis/urine microscopy	191	14.9	139	13.8	0.484
Overall	697	54.3	300	29.7	<0.0001

* ED: Emergency Department